of colored photographs that often elicited applause from the audience. This paper will be printed in full in the *Journal of the Anthropological Institute*. Dr. Furness has traveled a great deal in the far east and his comparisons of the Nagas with the interior tribes of Borneo will prove of value—as he knows them all so well, as is proved by his recently published magnificent volume on "The Home-life of Borneo Head-hunters" (Lippincott Co.) and by the very valuable collection he has given to the Free Science and Art Museum of Philadelphia. Dr. Furness does not find a very close resemblance between the Nagas and Borneans which some have expected should occur. The Report of the Students Ethnological Survey of Canada Committee is practically nothing more than a memoir by Mr. C. Hill-Tout on the Mainland Halkōmē'lEm, a division of the Salish of British Columbia, but more especially with the Tcil'qē'uk and Kwa'ntlEn tribes of the Lower Fraser River. These ethnological studies run to over ninety pages, the greater number of which are devoted to linguistics. The Royal Society of Canada has at least awakened to the importance of recording the rapidly vanishing lore of the Canadian aborigines and it is to be hoped that some action will now result and that the Canadian government will assist in this important national work. The reading by Mr. J. L. Myres of a suggestive paper written by Dr. W. H. Holmes, entitled "The Classification and Arrangement of the Exhibits in an Anthropological Museum" led to a very interesting discussion in which Dr. W. E. Hoyle, Professor Boyd Dawkins, both of the Manchester Museum, Mr. H. Balfour, of the Pitt Rivers Museum, Oxford; Mr. G. Coffey, of the Royal Irish Academy Museum, Dublin; Mr. E. Lovett, and Dr. A. C. Haddon took part. Several speakers referred to characteristic features of American museums and pointed out some of the ways in which the English museums could be rendered more instructive and popular. It is beginning to be realized that a museum should be the educational center of a town, but in order to be that it must itself first be educational in its scope.

H.

SPECIAL ARTICLES

THE PRESENCE OF WATER VAPOR IN THE ATMOSPHERE OF MARS DEMONSTRATED BY QUANTITATIVE MEASUREMENTS

IN 1867, Huggins first announced his detection of a slight intensification of the bands of aqueous absorption in the spectrum of Mars. The observation was an exceedingly delicate one, and resting, as it did, solely on eye-estimates of the relative intensities of weak lines which certainly do not differ very much in appearance, it is not remarkable that other observers, with even more powerful instruments, have declined to endorse the supposed intensification of aqueous bands, and have even denied its existence. Vogel, indeed, came to the aid of Huggins in 1873, and the opinion of two such accomplished observers was worth something. The question, however, up to the present time, has remained a matter of opinion only, with the honors about equally divided, the Lick observers declaring positively that no intensification was visible.

Under these circumstances, Professor Lowell's announcement that Mr. V. M. Slipher had succeeded in photographing the little *a* band in the spectrum of Mars under conditions which left no doubt of its relatively greater strength, may have passed with some as no more than a fresh subject for incredulity, and one to be relegated to the same limbo of "matter of opinion." I therefore resolved to try to place these observations on a more solid basis, and with material aid from Professor Lowell, who has generously placed at my disposal the means for testing my ideas, I am now able not only to confirm Mr. Slipher's discovery, but to give numerical values for the amount of intensification of the *a* band. Besides this, it now becomes possible to give an approximate estimate of the amount of water vapor which is present in the air of Mars.

The instrument with which the examination of the spectrograms is made, I call a spectral band-comparator. It can be used for comparing the intensities of either lines or bands in two different spectra, but was more especially intended for the examination of

faint or diffuse bands in spectra of small dispersion, whence the name. After trial of other comparison objects, I conclude that nothing succeeds as well for the purpose of matching one of these hazy bands in a photograph of the spectrum as an equivalent, but not identical line or band in another spectrum of identical intensity as to the general background of continuous spectrum. The comparison line is chosen both narrower and brighter than the one to be measured in order that, when placed a little out of focus by a displacement of the objective of the microscope with which it is viewed, it may appear both broader and fainter, and may thus resemble the object with which it is to be compared. Beyond this, the observation consists simply in repeated settings of the microscope in its out-of-focus position corresponding to apparent equality of the hazy bands, and in the determination of a curve of brightness by a careful photometric calibration of the scale of the instrument.

The measurement is safeguarded in every possible way, and especially by duplicate measures, made on each one of the plates, of a line which is certainly solar and not subject to modification by the atmospheres of the planets. For this purpose the hydrogen *C* line has been made a test object, and also a means by which the measures on little *a* may be corrected for trifling variations in the focus of the spectograph in the intervals between successive spectrum exposures.

The measures on great *C* in the spectra of Mars and the moon, taken at Flagstaff by Mr. Slipher at such times as to give equal altitudes for the two bodies at midexposure, and for such durations as to produce equivalent intensity of spectral background under identical photographic development, have a ratio which never departs much from unity; and the average ratio for all of the plates measured approaches unity much within the limit of the probable error. On the other hand, similar series of measures on little *a* show without exception that little *a* is more intense in the spectrum of Mars than in that of the moon, with equal *C* lines and for equal altitudes.

The average value of the direct readings of the spectral band-comparator makes the intensity of *a* in the spectrum of Mars $= 1.224 \pm 0.0245$. The observations in full may be found in *Lowell Observatory Bulletin,* No. 36.

This result requires further correction by means of a calibration curve for the readings of the spectral band-comparator, before it can be stated in absolute units. To obtain such a curve, I have measured the disappearances of the same spectral line at various settings of the instrument with the modification of Pritchard's wedge-photometer invented by Dr. Charles H. Williams, of Boston, and called by him a "simplex" photometer. It is a well-known fact that the eye is much more sensitive to slight variations of intensity than we might have anticipated. But just as we do not recognize our faculty of discrimination, neither do we recognize how great the actual differences of intensities of illumination may be which correspond to our fallacious impressions of the same. Differences of illumination which we note immediately, but which are not judged to be great, which in fact, at first guess, we estimate as but a few per cent., turn out to be many hundred per cent. when made the subject of exact measurement. It is probable that very few would guess in the absence of exact measurement that a first-magnitude star is one hundred times as bright as a sixth magnitude. Bearing these facts in mind, it need excite no surprise when I state that the actual ratio of intensity of the *a* band in Mars, when expressed in absolute units, is much greater than would at first be inferred from the direct readings. I find that the real intensity of the band in the spectrum of Mars in the month of January, when the dew-point at Flagstaff was about 20° F., was *four and a half times as great* as in the lunar spectrum at the same altitude.

I have endeavored to find out how far it is possible for this result to have been vitiated by inequalities of photographic development. Some of the spectrograms of Mars have been over-exposed, but by a detail in the mode of procedure to which only incidental allusion has been made, namely, by altering the illumination of one or the other of the spectrograms

until identical illumination has been obtained, this diversity of photographic action, due to variation of exposure, or of development (of course with the proviso that such variations are never excessive), is apparently taken care of. At any rate, I find no difference in the results which can be traced to this cause.

Admitting that the little *a* band is four and one half times as intense in the spectrum of Mars, if we may assume that the intensity of the band is proportional to the total amount of vapor present in the combined air columns traversed by the rays, as it is very nearly in the case of incipient absorption, it is perhaps permissible to say, since the rays pass twice through the atmosphere of Mars, that on the average Mars has $0.5 \times (4.5 - 1.0) = 1.75$ times as much aqueous vapor in its atmosphere as that which exists above Flagstaff in the month of January, or roughly, since one and three quarters times the amount of water vapor in the surface air of Flagstaff would be 2.17 grains per cubic foot, or 5.0 grams per cubic meter, it may be concluded that the dew-point on Mars would be 33° F., if the distribution of moisture were the same in the upper air of the two planets. In this respect, however, there is a very wide divergence of conditions on the two worlds, since, as I have shown in my paper on "The Greenhouse Theory and Planetary Temperatures," in the *Philosophical Magazine* for September, 1908 (p. 469), the proportion of aqueous vapor existing at great elevations above the surface on Mars is very much greater than here. This is due to the comparatively rare atmosphere of Mars, to the low boiling point of water on that planet where water evaporates much more readily than here, and to the prevailing desert conditions, that is to say, to the infrequency of those atmospheric conditions which conduce to the formation of cloud and rain. Through these causes, aqueous vapor on Mars diffuses to greater heights and remains suspended in the air for longer intervals than with us. As a consequence, although there may be a very extensive protecting mantle of highly absorbent vapor which prevents surface radiation and conserves surface temperature, the dew-point at the surface remains low, probably seldom rising much above the freezing point, and the prevalent conditions on Mars are those of a mild but desert climate, as Professor Lowell has all along maintained.

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THE SELACHIANS ADMITTED AS A DISTINCT CLASS

EVER since 1873 (*Am. Journ. Sci.* (3), 6, 434, 435) I have claimed class rank for the Selachians or Elasmobranchiates. This view has been later accepted by most American ichthyologists, and notably by Jordan, since 1902.[1] At last two European naturalists, of great eminence, have come to the same conclusion.

Professor A. A. W. Hubrecht, in the *Quarterly Journal of Microscopical Science* for November, 1908 (p. 156), has stated that "a division of the vertebrates in the superclasses of Cyclostomata, Chondrophora, and Osteophora might suggest itself, Amphioxus remaining yet more isolated in its superclass of Cephalochordata. The CHONDROPHORA would then contain the Elasmobranchs, the OSTEOPHORA all the other higher vertebrates."

Mr. C. Tate Regan, in the *Annals and Magazine of Natural History* for January, 1909 (8. ser., 3, 75), has recalled that he had "already expressed the opinion that the true Fishes are at least as distinct from the Selachians, on the one hand, and the Batrachians, on the other, as any of the vertebrate classes are from each other, and are equally entitled to rank as a class,"[2] and insists on their claim to class distinction.

Hubrecht and Regan, it is true, are not the first or only European naturalists to differentiate the Selachians as a class from the Pisces, for Geoffroy Saint-Hilaire and La-

[1] Up to 1887 Jordan had regarded the Selachians as a "class Elasmobranchii"; from 1888 to 1902 he associated them with the Pisces under two subclasses, Selachii and Holocephali; in 1902 he reverted to his former view. (See "Guide to the Study of Fishes," I., 1905, pp. 506, etc.

[2] Regan, *Proc. Zool. Soc.*, 1906, p. 724, and "Biol. Centr.-Am.," Pisces, p. viii (1908).